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A SIMPLE DISCUSSION OF WORLD VIEW ASSOCIATED WITH THE
DEVELOPMENT OF ASTRONAVIGATIONAL TECHNOLOGY
SINCE THE SUCCESSFUL LAUNCH OF AUSTRALIAN SATELLITES

Lu Fengxian Xi Rizi

Translation of "Cong Ao Xing Fa She Cheng Gong Qian Tan Fa Zhan Hang Tian Ji Shu De Jia Zhi Guan"; Aerospace China, No.6, June 1993, pp 3-6

The 14th of August and the 21st of December 1992 are two extremely unusual days in the history of the development of Chinese astronavigation. In accordance with contract requirements, use was made of the Chinese Long March No.2 strap on type carrier rocket (simply called the LM-2E) to launch, one after the other, two Australian new generation high capacity communications satellites manufactured by the U.S. Hughes company into predetermined orbits. This achievement gave rise to extremely large reactions domestically and abroad--raising national prowess and stirring the hearts of the People. Comrade Song Jian, who is both head of the State Affairs Committee and the National Science Committee, spoke in praise of it saying, "This is a new milestone in the history of the development of Chinese astronavigational activities." It clearly shows people, in a convincing way, that China possesses the capability to launch large model communications satellites--thus opening up for China the international astronavigational launch market, breaking through the blockade, and taking big strides toward showing the world the broad prospects. A firm foundation is laid for the future development of Chinese astronavigational enterprises. At the same time, the necessity and importance of developing Chinese astronavigational technology is also fully and

clearly shown. Premier Li Peng has pointed out recently that, "Successful development of the LM-2E rocket is the most important achievement in Chinese national defense science and technology and even all of high technology in recent years." Now, using the successful "Aussat" launches as an example, an analysis will be made of the value of developing Chinese astronavigational technology as well as prospects for carrying this out hereafter. As far as this is concerned, guidance with regard to our strengthening "accelerated development of astronavigational technology and striving for a new step up" will necessarily have wonderous benefits.

I. POLICY MAKING ASSOCIATED WITH "AUSSAT" LAUNCHES AND LM-2E ROCKET DEVELOPMENT PROCESSES

On 1 November 1988, the assistant general manager of China's Great Wall general industrial company, Wu Keli, represented the Chinese side in the formal signing with the U.S. Hughes company of contracts associated with Chinese-U.S. "Aussat" launch services. As far as contract stipulations are concerned, before June 1993, China would use the LM-2E rocket to send the two Australian Aussat B1 and Aussat B2 satellites into orbit.

The LM-2E is a type of new model, large thrust, two stage carrier rocket which opts for the use of strap on technology in China's carrier rocket series. It uses the mature technology of the Long March No.2 carrier rocket as foundation. On the periphery of the first stage rocket, there are positioned 4 liquid boosters with diameters of 2.25 meters and heights of 15 meters. The overall rocket length is 51 meters. There are a total of 8 engines. Lift off weight is 460 tons. Lift off thrust is 600 tons. It is capable of taking 9.2 tons of useful load and launching it into near earth orbit. If an upper stage is added, it is then capable of taking 2.5 ton to 4 ton spacecraft and sending them into geosynchronous orbit. At the present time, it is the type of Chinese rocket with the largest carrying capability. It is

also one of the world's large model commercial rockets.

In January 1989, work on development of the LM-2E formally began. In normal situations, the development of a new model of rocket like the LM-2E outside of China would require at least a three to four year period of time. However, in this instance, China, by contrast, required 18 months for successful development. This is a very arduous and formidable task. It is undoubtedly also a severe test. As far as the astronavigational fighters (illegible) participating in the development of LM-2E and the launch, telemetry, and control associated with the "Aussat" firings are concerned, they pressed forward in the face of difficulties, daring to wrestle with and eliminate ten thousand hardships--selflessly making contributions and expending huge amounts of painstaking care and labor. In a very, very short 18 months, development and testing of the new model rocket was then completed. In conjunction with this--within an extremely short period of time--construction was completed on all launch, vibration testing, as well as telemetry and control facilities included within new models of gantry in order to carry out, within contract time limits, launch tests, creating all necessary preparatory conditions. In July 1990, the LM-2E was successfully test fired for the first time, winning international prestige. However, the road was certainly not smooth. In March 1992, as far as the first formal "Aussat" firing is concerned, it was discontinued due to the occurrence of accidental malfunctions. The whole company of personnel participating in development and testing underwent the hardships of failure. With indomitable willpower and using a time period of only 17 days, they checked it out, and thoroughly eliminated the malfunctions. After that, two regular firings were successful one after the other, satisfactorily completing cooperative international space missions possessing great significance. This signified, after successive firings of the "Assat", that Chinese astronavigational technology had again reached a new level.

II. A SIMPLE ANALYSIS OF THE VALUE OF DEVELOPING ASTRONAVIGATIONAL TECHNOLOGY FROM "AUSSAT" LAUNCH SUCCESSES

The LM-2E rocket technology associated with the launching of "Aussat" is the newest achievement of China's astronavigational technology. It is also the epitome of the development of China's astronavigational activities. As far as the difficulties associated with the coming of this victory are concerned, it went through a very good number of years of struggle able to move one to songs and tears. It will certainly be entered into the history of the development of China's astronavigational technology. The concept of the value of commercial products associated with Marxism recognizes that, in all cases, there is a use value and a value. The successful "Aussat" launches gave people a great deal of new inspiration. In particular, it caused people to construct a type of new value system. It exhibits values associated with the several areas below.

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1. It is a political proclamation that the Chinese nation is standing on its own feet among the peoples of the earth.

China possesses an age old history. In conjunction with this, it is one of the national cultures which have given to the world imperishable contributions. However, the recent history of China is still one of blood and tears. "Fall behind, and you will then get a beating." This is nothing else than the bitter lesson that comes down from history.

On 1 October 1949, Chairman Mao Zedong announced solemnly to the whole world: "From this time forward, the Chinese nation is standing up." The Chinese people welcomed the coming of the new historical epoch. In the middle 1950's, the economy of China was still very backward. At the time when all neglected tasks awaited undertaking, the Party and the Nation then resolutely resolved to construct and develop China's astronavigational activities.

Going through a course of struggle with winds and rains for several decades--in accordance with self-reliance and arduous striving--we ended by grasping strategic and tactical missile

technology--putting out a carrier rocket series and various types of satellites (illegible) floating in space. China's returnable type satellites, metrological satellites, and geostationary orbit communications satellites, as well as remote control and telemetry control technolgies, etc, have already entered into advanced world ranks. In carrying capability, LM-2E has gone up another level. Its carrying capability has already lept into world front ranks. In and of itself, this not only clearly shows the intelligence, ability, and wisdom of the Chinese people as well as powerful and prosperous combined national strengths, it also proves their capability to stand on their own among the peoples of the world. Just as Comrade Deng Xiaoping has incisively pointed out, "If China in the 1960's had no atomic bomb, hydrogen bomb, had not launched satellites, China would then not be called one of the three great powers--would not then have this kind of position. These things reflect the capabilities of a people. They are also the sign of a people and a nation that is flourishing and developed." The facts bear this out. In July 1990, when the LM-2E rocket towered aloft awaiting launch, the deputy director general of the U.S. Hughes company said to the general engineer for this rocket, Wang Dechen, "A year ago, I said that China wanting to realize the LM-2E kind of huge engineering project is a halucination. Today, I see with my own eyes the realization of this project. I apologize to you. If the launch is successful, the whole world will greatly admire you." After the success of the first "Aussat" launch, he was nothing but praise--convinced that the Communist Party and China were capable of creating wonders which people had not imagined. During the whole process of cooperation, it is possible to cause a concrete recognition of "a great and strong China" like a U.S. cooperative partner. Is it not difficult to believe that this is not the power of LM-2E "Aussat" launches and even the actual strength which is shown by Chinese astronavigational technology?

2. It is a vivid embodiment of the superiority of the Chinese Socialist system.

At the end of December 1988, when the LM-2E rocket development mission was started, an annual All China materiel ordering conference had already been opened. However, in order to determine materiel urgently needed for LM-2E, relevant national departments and committees also called specialized materiel emergency ordering meetings. Development units and over 300 factories associated with 24 provinces and 74 cities all over China signed over 5000 materiel procurement contracts. Immediately--like three great campaigns in wars of liberation that year--from north to south, from east to west, several thousand units and several hundred thousand troops surrounded an objective, twisting the rope, keeping in step, and cooperating closely. After July, the over 7000 items urgently needed for rocket development, the over 1100 types of electrical products, and close to 600 thousand electrical components were shipped ceaselessly from sources here and there to development units, supplying reliable materiel guarantees in order to complete development within 18 months and launch successfully. This kind of efficiency is seldom seen in the history of world astronavigational development.

This is nothing else. This is precisely the location of the superiority of the Socialist system. This is nothing other than to say that, under a Socialist system, it is possible to concentrate our nation's full advantages, bring to bear full effects, concentrate and unify to a high degree, spending less money and doing more with it, taking care of matters. Comrade Xiaoping says, "It seems that the Socialist system is capable of concentrating strengths--bringing several great works to completion." As far as the appearance of the wonderous success associated with the development of LM-2E is concerned, with regard to Chinese astronavigational technology--in a situation where economic and industrial foundations are very backward--the achievement of rapid development is, in all cases, a vivid embodiment of Socialist superiority.

3. It is a realization of great surpassing breakthroughs in astronavigational technologies.

The development of the LM-2E carrier rocket was an enormous, complicated instance of systems engineering. Its technological links were many. The disciplines involved were many. In particular, lengthening of the rocket in a longitudinal direction and transverse directional strap on involved a good number of key technologies--for example, parallel connection structural dynamics, attitude control, booster rocket connection and separation, propellant utilization, large model satellite cowlings, large model ground launching pads, full rocket vibration towers, as well as new structures, new materials, new industrial processes, and such technologies as these. As far as breakthroughs associated with these key technologies are concerned, they make carrier technology reach a new level, opening up new technological paths for using strap on forms to develop larger and newer carrier rockets--advantageous to China maintaining the international position of an astronavigational technology great power.

On 14 August 1992, the LM-2E carrier rocket took "Aussat" and put it accurately into predetermined orbit. Launch angles of inclination were accurate to 1%. At perigee altitudes associated with distances of 200km, variances were only 0.9km--much, much smaller than the permissible deviation of "plus or minus 6km". At apogee altitudes associated with distances of 1050km, variances were only 3.8km--also, in the same way, much, much smaller than the permissible variation of "plus or minus 12.4km". The three parameters above all far, far exceed the requirements associated with "Aussat". Orbital entry precisions exceeded the "Assat", which world astronavigational circles believe is the best. Even Hughes company experts all had no choice but to recognize that it was the most precise orbital entry of all the carriers of Hughes satellites. It is possible to say without bragging that LM-2E carrier rocket technology brings together the best results associated with Chinese astronavigational technology. It is a new milestone on the march of Chinese astronavigation toward the future. Among the advanced, large thrust carrier rockets of the world, it is certainly not inferior.

4. It is a typical representative of small investment and high output. /5

Another important characteristic of the development of Chinese astronavigational technology is small investment and high return. Comparing the European Arian rocket and China's LM-2E rocket, which have equivalent carrying capabilities, the former was developed in 7 years at a cost of 800 million U.S. dollars. Investment in the latter, however, did not reach one third that of the Arian rocket, and the development time used was only 3 and a half years. No wonder experts associated with the Long March rocket series are able to achieve this type of amazing formula: 1 yuan Renminbi equals 2.5 U.S. dollars. This type of low investment and high benefit is unique in the world. On the basis of statistics from relevant national departments, in 36 years, the investment which China has used in astronavigational activities has not reached 0.5% that of the U.S. or 14% that of western Europe. It is only equivalent to the investment associated with the first phase of a Chinese steel project.

Not to mention the entirety of the benefits brought into play in association with the 35 satellites which China has already launched up to the present time--taking only the "75" period, China used an investment of 600 million Renminbi and developed a total of 11 applied satellites which were successfully launched. The direct economic benefit is 4.3 billion Renminbi. One should say that economic benefits are very high.

Secondly, achievements in astronavigational technology are transplanted into industrial departments, spurring development of the national economy. For example, rocket motor combustion technology is already applied in the remodeling engineering associated with China's over 20 units of large model oil fired industrial furnaces, realizing automatization of production, very, very greatly reducing the degree of labor intensity, alleviating air pollution, safeguarding the environment, and bringing huge economic benefits for factories. As far as this one item alone is concerned, it is possible--for enterprises and the nation--to

increase profit taxes over 200 million yuan each year. For another example, special types of valve technology associated with rockets have spread to petrochemical activities--also achieving marked results. On the basis of incomplete statistics, the whole petrochemical industry has over 250 thousand sets of valves. As far as the valves in question are concerned, they require strong anticorrosive equipment properties and good levels of seal. Machines are shut down and domestically produced components are replaced once every 7 days. Machines are shut down and imported components are replaced once every 15 days--severely influencing the production efficiency of the enterprises. Carrier rocket research institutes used comparatively short periods of time to develop products which operate stably, are convenient to use, simple to maintain, and have a long service life--laying a firm foundation for "safe, stable, and long" enterprise production. Besides this, with regard to the development of astronavigational technology propulsion raw and processed materials, component industries, metallurgy, chemical industries, electronics, technological manufacturing enterprises, as well as basic sciences, the economic benefits are also difficult to assess.

5. Successful "Aussat" launches retemper the spirit for astronavigation.

From the successful development of LM-2E rockets in 18 months to the first launch--from the "3.22" setback to the "8.14" success--it all shook the world--all tested peoples spirit and styles of work.

Since the State Council officially approved development of the LM-2E carrier rocket, facing development personnel there has been this schedule which is difficult for people to accept waving in front of them. It was necessary, within 100 days, to resolve 20 key items of technology such as rocket structural dynamics and coupling analyses, strap on connections, booster separation, and so on. 24 sets of 440 thousand design diagrams were completed for the whole rocket. Within 400 days, over 5000 sets of special work clothes were designed and produced. Over one hundred thousand spare parts

were produced. Within 180 days, close to 300 ground experiments were completed--such as rocket mock ups, subsystems, comprehensive coupling tests, as well as booster strap on and separation, whole rocket vibration, and so on..... . In accordance with conventional requirements, completion of these tasks needs 3 to 4 year time periods. Even in the U.S., which is very rich in material and technological conditions, it still takes at least two and a half years. It was necessary, within 540 days, to carry through activities which can only be completed in 5 years. In conjunction with this, to guarantee the success of the first test flight in July 1990, there was not only no precedent in China. Even in the eyes of the astronavigational great powers of the world, who invest tens of billions of U.S. dollars a year, it was, in the same way, also little short of "Arabian Nights". As a result, the former deputy director of the U.S. McDonnell Douglas astronavigation company, the deputy general engineer for the Atlas rocket, and the Hughes company's specially invited technology consultant, Mr. Shimisi (phonetic), excitedly exclaimed, " How is it possible, in this short a time period, to develop a new model rocket, and, in conjunction with that, complete construction of the firing range? This big a project needs three or four years even in the U.S.!" The tenacious grappling of this astronavigational contingent in the days and nights of those 18 months turned out an amount of work which is difficult to imagine.

What is even more moving to people is that, on 12 July 1990, in the afternoon four days before the first flight of the LM-2E, pulse pressure sensors associated with the 4 boosters which were fully fitted and awaiting launch, developed leaks. If they had not been eliminated in a timely manner, the laborious achievements of 18 months would have been destroyed in an instant. At this sort of thorny critical moment, the threat situation is compelling. Scientific and technical personnel, workers, and cadre sprang forward together and immediately organized "emergency squads", braving dangers to their lives to drill into fuel tanks which were filling the air with acutely toxic gases to block leaks and

eliminate the danger. As soon as one of them fell another stepped in. Not one person shrank back. In just this way, a particularly grave accident, which was just on the verge of occurring, was averted.

On 22 March 1992, the "Aussat" LM-2E gave rise to malfunctions and an emergency crisis, stopping the launch. This contingent underwent enormous mental pressure and heavy psychological burdens. With tenacious stamina, they only used a very short period of time and then checked out and, in conjunction with that, eliminated the malfunctions. Using only a 100 day time period, over 1000 production items and test measurement tasks, which normally require at least 6 to 8 months for their completion, were managed, ending with the sending of "Aussat" aloft. In the last several decades, astronavigational fighters used selfless labors to cast spiritual arrows, also forging themselves into a contingent with good ideology, technical skill, hard styles of work, and the ability to attack and fight well. During a blockade, they broke out with the national prestige. Under pressure, they created wonders. In poverty, they accomplished great works. An Assat company consultant who has participated in over ten launch missions said, "China has a batch of the most outstanding rocket experts, has a group of high level orgnaizational and command personnel. Even internationally, they are still capable of being the most excellent." What is controling the common astronavigational personnel to create splendors one after the other? This is nothing else than the spirit of astronavigational tradition formed over the last more than 30 years. "Self-reliance, arduous struggle, vigorous cooperation, selfless contributions, rigorous realization of tasks, courage to climb". This is the spiritual wealth associated with China's astronavigational activities' constantly achieving victories and the source of its strength. Moreover, the course of the development of the LM-2E is also the next tempering for the astronavigational spirit--generally called "LM-2E spirit". It is a continuation, deepening, and development of the traditional spirit of astronavigation.

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III. PROSPECTS FOR THE DEVELOPMENT OF ASTRONAVIGATIONAL TECHNOLOGIES

The current development of astronavigational activities is astonishing. Spaceships land on the moon. Space shuttles rise into space. Space stations carry people for long term flights. Outer space exploration expands constantly, and so on, and so forth. Since the 1980's, several economically developed nations and groups of nations such as the U.S., the Soviet Union, Japan, western Europe, and so on have struggled with respect to outer space, developing a comprehensive contest of national powers using the development of high technologies and the development of industries promoting high technologies--using forms which attempt, through outflanking and not direct military resistance, to seize this key realm associated with world hegemony in the 21st century.

The development of astronavigational technology is not only capable of playing a huge role in military affairs. It is, moreover, capable of playing a very large role in the development of the national economy and society. It will necessarily bring benefits to mankind in broader and broader and deeper and deeper ways. As far as space--the fourth realm associated with mankind's knowledge, applications, and development--is concerned, it will become the main motif associated with astronavigational activities in the 21st century. With regard to its effective means and paths, one is to make use of automatizaton associated with unmanned spacecraft--satellites, platforms, balloons, and sounding rockets. A second is to make use of manned spacecraft--space stations, spaceships, space shuttles, space planes, and so on. Looking at the state of development of world astronavigational technology at the present time, one time use carrier rockets will still play an important role on the stage of the entry of mankind itself or of unmanned spacecraft into space. Following along with constant improvements in astronavigational technologies, a new generation is capable of multiple use space surface round trip carrier systems--

including the inevitable development of a new generation of space shuttles as well as space planes which do not need carrier rockets to enter space.

Acting as a developing nation, whether Socialist China has the courage and the capability, on the stage of this rapid and frenetic development of world high technology, to maintain its own position and image--this is a rigorous and pressing challenge. Using actual needs and possibilities, development guidance associated with China's future astronavigational technology should be concentrated on finite targets and sequenced development. We will continue to develop applied satellites and satellite applications, studying and developing manned astronavigational technology. In order to realize the objectives described above, the key to everything is nothing other than the need to take carrier rockets in the direction of large thrusts, high precision, and high reliability. Here--besides the need to develop new and even more advanced propellants--the combination for the first time of LM-2E carrier rockets together in series and parallel technologies opens up effective technological paths associated with the development of carrier rockets with even greater thrust. Following this path, the LM-3E (that is, the addition of an oxyhydrogen motor stage on top of LM-2E carrier rockets, which is capable of taking 2.5-4 ton spacecraft and pushing them into geosynchronous orbits) is a development success which will not be long in coming. In order to promote this, China must use a grand astronavigational plan of its own realized step by step--reaching victory on the other shore. This is certainly indisputable.

We are firm in the belief that future prospects must be even more splendid.

IRAQI SPACEFLIGHT ACTIVITIES

Gao Peng

Translation of "Yi La Ke De Hang Tian Huo Dong"; Aerospace China, No.6, June 1993, p 6

Iraqi spaceflight organizations include the Iraqi Spaceflight Research Center (ISRC) and the national telecommunications bureau. ISRC is subordinate to the scientific research committee, located in Baghdad.

The outside world knows very little about Iraqi astronavigational activities--only that, before the 1990 invasion of Kuwait, news circles had reported that Iraq planned to carry out a satellite launch at the end of August 1990. Besides this, what the world mainly knew about Iraqi spaceflight activities was the development of the Tamous 1 rocket.

The Tamous 1 rocket is 24.4 meters long. It weighs 48 tons. It opts for the use of liquid propellant. It is capable of sending a useful load of 150kg into near earth orbit. On 5 December 1989, the Tamous 1 was launched for the first time from the Al Andbard pad 80km west of Baghdad. The rocket in question is 11 meters long, has a maximum diameter of 2.3 meters, and the thrust is 686 kilonewtons. The first stage is composed of 5 improved model Abasi (phonetic) missile motors from Fleet Footed Runner (SCUD) missiles. The second stage is also an Abasi (phonetic) missile stage 9 meters long. The third stage rocket is 3.5 meters long.

A 1989 report clearly showed that Brazil would provide to Iraq a type of SCD environmental platform data collection satellite and also referred to there being the possibility of receiving technological cooperation from France and the former Soviet Union.

1990 press reports said that Iraq may possibly be in the process of implementing a project called "Babylon"--that is, the construction, by the Bulusaier (phonetic) spaceflight research company of a small model Supergun satellite and also including taking a small model useful load and sending it into low earth orbit.

Iraq is also a signatory of the international satellite organization and the international maritime satellite organization.

DEVELOPMENT TRENDS IN COMMUNICATIONS SATELLITES
AND THEIR APPLIED TECHNOLOGIES

Wang Jingquan

Translation of "Tong Xin Wei Xing Ji Qi Ying Yong Ji Shu De Fa Zhan Qu Shi"; Aerospace China, No.6, June 1993, pp 23-24, 26

I. SATELLITE TECHNOLOGIES

1. Useful Load Technologies

(1) Repeaters

The primary development trends associated with satellite repeaters are reductions in the weight and volume of useful load hardware, raising effective omnidirectional radiated powers, frequency spectrum efficiencies, and reliability.

-Receiver Technology This includes integrated technologies such as low noise, front end, single chip microwave integrated circuits, and so on, as well as dielectric wave filter devices. In particular, dielectric wave filters--for example, dual mode or triple mode resonance cavity wave filter devices have had their volumes and weights reduced to one tenth those of the originals. They are capable of providing ideal microwave filtering networks for radio frequency signal separation and combination, causing frequency spectrum efficiencies associated with multiple user satellite communications systems to have sweeping increases. Dual mode wave filter devices are already used in the Ku wave band. Triple mode wave filter devices are already used in the C wave band. As far as sonic surface wave filters are concerned--besides

wide ranging applications in intermediate frequency systems--L wave bands are also successfully used now.

-Onboard Satellite Processing Technologies Used in mobile and fixed communications services, these primarily include onboard satellite processor and point beam antenna modulator/demodulator integrations, time and space cut overs, on board satellite storage, and so on. Far ranging applications of microband technologies and microwave integrated intermediate circuits have caused microwave matrices to achieve realization. In particular, after the development of base band processing technologies, complex techniques associated with satellite onboard switching were resolved.

-High Power Amplifiers These primarily resolve high powers, linearity, and reliability--including traveling radiation and fixed radiation. In traveling radiation technologies, helix techniques are the key to the realization of high powers and high frequencies. Fixed radiation technologies primarily resolve field effect transistor parallel connection technologies and heat dissipation techniques.

-Chain Circuits Between Satellites and Onboard Satellite Processing Technologies They will develop jointly. They are primarily used in long range connections and connections associated with families of satellites--including laser diodes, avalanche photodiodes, CCD sensors, wave length multiplex technologies, as well as ammonium-yttrium aluminum garnet lasers, and so on.

In order to resolve problems of orbital crowding, scholars associated with Japan's Hokkaido engineering institute put forward new concepts of groups of stationary satellites with optical cable systems, advancing the use of cables vertically to take as many as 9 satellites and connect them into a series, and, in conjunction with this, point them toward the center of the earth. The system in question becomes one entity which has a stable vertical gravity gradient, turning around the globe together with the geosynchronous period. It will spread out up and down from geosynchronous orbits, making a series of 9 satellites all become stationary orbit

communications satellites. Optical cables between satellites also take communications systems and connect them into one, making communications capacities increase by 10 fold. This makes link circuits between satellites even more reliable. The regions covered by various satellites are also conveniently connected with each other.

(2) Antenna Technologies

-Antenna technologies are primarily developing toward multiple beam antenna techniques--including focusing reflectors, directional radiation arrays, imaging reflectors, lens type antennas, and so on. Antenna molding technologies have already developed to a new stage, combining 110 trumpet feed sources. In conjunction with this, use is made of phase range computer controled feed source systems, causing coverage ranges associated with transmissions to the surface to be capable of arbitrarily forming into the required shapes--moreover, guaranteeing comparatively intense powers in covered zones. At the same time, it is also possible, on the basis of requirements, to take a coverage zone and divide it again into 2 or 4 or more subareas. Due to the fact that option is made for the use of new forms of materials such as graphite fibers, polyethylene, as well as silver films, and so on, the weights of antennas and transmission trumpet horns can be very, very greatly reduced.

Wave guide switch technology has already caused cut-in losses to fall to 0.05dB or less. In new models of wave guide subsystems, within one wave guide tube, it is possible to simultaneously transmit as many as 12 microwave signals--very, very greatly developing capacities associated with antenna feed lines.

2. Satellite Common Use Modules

(1) High Power Electric Sources

High power electric sources are primarily developments of gallium arsenide solar cells and composite batteries associated with gallium arsenide and silicon in order to obtain relatively good radio frequency penetration capabilities. Power storage

batteries are primarily nickel hydrogen batteries, sodium sulfur batteries, and lithium batteries. In a good number of three axis stable satellites, most opt for the use of designs that exceed dimensions by 25%-30% to make satellites capable of operating at full power when placed at maximum β angles.

(2) Heat Control

Developments are primarily of deployable type radiators and liquid heat dissipation systems, casing satellites to possess comparatively good capabilities to lower temperature gradients and making use of moving radiation and fixed radiation of amounts of heat into space.

(3) Attitude Control and Orbit Control

New generations of satellites opt for the use of reaction wheels, solar moments of rotation, magnetic moments, as well as momentum wheels associated with universal joints, and so on.

The next step in development trends is to opt for the use of satellite onboard processors to improve the autonomous control capabilities of satellites in order to facilitate lowering reliance on ground controls.

(4) Inclined Orbit Operations

A good number of satellites operate past orbital design lives, after which, they still have a number of subsystems in operation. Onboard satellites, if there is not enough propellant to maintain orbit--besides making them go out of service--it is still possible to let them operate in an inclined orbit. At this time, the propellant required is comparatively little. All that is needed is to possess the capabilities to calibrate communication, telemetry, and control antenna pointing errors.

Going through many years of practical realization and research, the U.S. satellite company COMSAT put forward a way of being able to extend the lives of satellite bodies and save satellite investment funds. They discovered that correcting north south position drift (orbital inclination calibration) in satellite orbits consumes fuel that accounts for 90% of the total amount of fuel used. As a result, the implementation of satellite north

south directional inclined operations is capable of very, very greatly extending satellite life. After entering into this type of operational mode, it is possible to extend satellite life 3 years (the drift range limit is 3°). It is possible to save the equivalent of satellite investments of 58 million U.S. dollars. Moreover, increased investments associated with ground station antenna tracking equipment only account for a very small part of this. The reason for this is that, after satellites enter into inclined orbital operations, antenna beams irradiating the surface have a periodic movement in a north south direction and a 24 hour periodic rotation. As a result, there are not only requirements with regard to antenna beam aiming capabilities when satellites are in inclined orbit operations. Compared to just aiming at geostationary orbit satellites, it is also necessary to add some needed equipment.

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(5) Ion Propulsion Technology

As far as opting for the use of a technology that consumes little fuel is concerned, it is not only capable of reducing the weight of satellites. It is also capable of extending satellite life. The reason is that ion propulsion systems are not only an order of magnitude greater than dual component propulsion systems (29.4kN•s/kg and 2.94kN•s/kg) in terms of specific impulse. Moreover, amounts of propellant consumed are only one tenth those associated with dual component systems.

The U.S. Hughes aircraft company has already developed a type of 25cm xenon ion propulsion device. Thrust is 63mN. Specific impulse is 28.4kN•s/kg. Power processing device input is 1400W. This type of propulsion device uses xenon ions accelerated in association with static electricity to produce thrust.

The xenon ion propulsion system developed in association with Japan's Mitsubishi electronics company is composed of 4 12cm propulsion devices. Thrust is 25mN. It is planned for use on Japan's engineering experiment satellite.

The xenon ion propulsion system developed in association with west Germany's MBB/ERNO consortium is a full boost subsystem. It

is planned for use on the Guanglika (phonetic) platform.

In the early 1970's, the mercury static electricity ion propulsion technology associated with the U.K.'s Kaluhamu (phonetic) laboratories was publicly recognized as occupying the predominant position. At the present time, development of xenon propulsion devices is just under way in cooperation with the Royal aircraft research center.

Due to certain technical problems during actual flights not being yet resolved, as a result, this type of propulsion system still has a ways to go to a mature stage. Due to a need to make use of batteries to supply electricity, there will be caused an increase of 2-3 fold in battery charge discharge cycle periods. This influences factors associated with battery life. At the same time, mutual influences of ion booster plasma and satellites will also lead to such problems as electromagnetic interference (EMI), electrostatic discharge (ESD), as well as materials contamination, and so on. In 1990, the international communications satellite organization and the Fute (phonetic) astronavigational company signed a contract to prepare to mount ion boosters on International Communications Satellite No.7.

3. Several Items of Improvement and Objectives Which Will Be Reached with Regard to Satellite Technology

(1) Lowering Weight

Subsystems the weights of which must go down as well as measures which are adopted are, for example, motor systems opting for the use of electronic propulsion and electric arc jets, service systems onboard satellites, structural composite materials, the overall mounting of flexible structures as well as the deployment of solar pointing systems, and so on.

(2) Improving Flight Life

This is primarily improvements in battery designs, the modularization of orbital displacement hardware, counter radiation characteristics of satellite parts, lowering hidden dangers of collision, propulsion system hardware, and so on.

(3) Improving Pointing Precision

Opting for the use of improved satellite sensor pointing structures and antenna beam controls.

(4) Other

Improving power utilization efficiency, that is, improving transformation efficiencies from direct current to radio frequency powers; improving beam widths and utilization efficiencies, that is, multiple uses of frequencies, modulation, multiple addresses, and system connectivity; improving the reliability of parts and entire machines; lowering weights of parts and entire machines; improving functional interchangability, for example, even higher levels of intelligence on board satellites; easy connection of users; improving data capacities to reduce cummulative delays; increasing flight life.

II. APPLIED SATELLITE TECHNOLOGIES

1. Services Compatible with Integrated Ground Service Data Networks

(1) VSAT

VSAT--making use of its ingenious flexibility, convenient installation, and inexpensive price (users can save 40%-60% on telecommunications investments)--is capable of undertaking various types of new communications services. In conjunction with this, it is capable of entering into the integrated services data network (ISDN) and has other similar advantages. It has become an important realm associated with satellite communications. Following along with the development of new models of technologies such as encoding, modulation demodulation, as well as error correction, and so on, and integrated technologies, VSAT is in the midst of developing from simple data forms toward the directions of such composite signal transmissions as data, voice, text, and graphics. In conjunction with this, it is just in the midst of expanding into such areas of application as agricultural village as well as long distance learning, and so on.

(2) Time Division Multiple Address/Speech Interpolation

In the International Communications Satellite system, at the present time, quantities are very large. Those with the most input are still such things as frequency division multichannel pertaining to analog technologies, frequency modulation, as well as frequency division multiple address, and so on. However, opting for the use of time division multiple address and digital speech interpolation (TDMA/DSI) it is possible to make repeater capacities increase 3 fold. With regard to single channel single carrier wave communications (SCPC)--opting for the use of this type of technology--it is possible to reduce numbers of channels and save on satellite power.

(3) Digital Circuit Backup Equipment

If 64kb/s channels which were originally used in transmitting single channel speech are combined with digital noninterpolation (DNI) communications, it is possible to obtain this type of multiple component low bit rate encoding signal. As far as users opting for this type of equipment are concerned, it is possible to very, very greatly reduce the transmission costs associated with each voice channel (saving 4/5). In conjunction with this, it is possible to obtain comparatively good control and relatively high efficiencies with regard to networks.

(4) International Business Services and Intermediate Speed Data Systems

With regard to international business service (IBS) transmissions of 64kb/s--8.44Mb/s--as far as 1/2 speed forward directed error correction data rates are concerned--they are used as communications between transnational group centers and sections, for example, digital speech, teletype, facsimile computer data, electronic mail, as well as teleconferencing, and so on. In the case of intermediate speed system (IDS) transmissions of 64kb/s--44.7Mb/s, 3/4 speed forward directed error correction data are concerned. As to these two types of applications, if bit error rates (BER) are better than 10^{-7} , system utilization rates reach as high as 99.96%.

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(5) Satellite Onboard Cut Over Time Division Multiple Address Technology

Opting for the use of satellite switched time division multiple address (SS-TDMA) technology compared to general TDMA, repeater capacities can improve 50%. The reason is that, in traditional TDMA forms, repeater up link and down link antenna beams are maintained invariable. Entire TDMA frames (2ms) are taken up by high speed digital signals (120Mb/s) associated with transmissions from up link stations to down link stations. However, in SS-TDMA, various repeater channels are capable of realizing dynamic mutual connections.

2. Other Services Which Are Not Compatible with ISDN

(1) Television

Digital television transmitted through satellites includes studio program transmissions, international television program distribution, cable television (CATV), direct broadcast (DBS), high definition television (TDTV), electronic news gathering (ENG), teleconferencing, VSAT associated with TV phone transmission video frequency imagery, and so on.

From now on, developments opting for the use of autoadaptive difference pulse code modulation (ADPCM) are fundamental in association with signal source encoding. At the same time, opting for the use of dispersion cosine transformation (DCT) and drift compensation technologies, it is possible to use comparatively low bit rates to achieve relatively good imagery quality. In conjunction with this, it is possible to combine data compression techniques with that, improving repeater efficiency and capacity.

(2) International Nets

As far as use in central stations and VSAT bidirectional data transmissions is concerned, 0.8 meter antennas will do. If option is made for the use of direct sequence expansion (code division multiple address), it is possible to overcome problems associated with low signal to noise ratios.

DEVELOPMENT STATUS OF BALLISTIC MISSILES
AND CRUISE MISSILES

Xu Hui

Translation of "Dan Dao Dao Dan He Xun Hang Dao Dan Fa Zhan Xian Zhuang"; Aerospace China, No.6, June 1993, pp 42-44

At the present time, a good number of nations all are in the process of carrying out various types of ballistic and cruise missile projects. There are approximately 34 nations or regions that are equipped with intermediate range ballistic missiles. The ranges of these missiles are between 70-4750km. These old model missile systems--for example, Puludong (phonetic), MGM-52 Lance, and SS-1 Fleet Footed Runner (SCUD)--will be very rapidly retired from service. What is adopted to replace them is a large number of newly developed missiles.

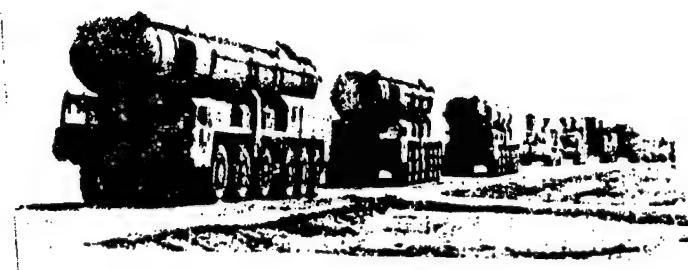


Fig.1 Russian SS-N-20 Submarine Fired Ballistic Missile

After the signing of the strategic arms reduction treaty (START), a number of old models of submarine launched ballistic missile systems (SLBM) will not see service again--for example, the SS-N-6 and UGM-73 Poseidon missiles will be retired from service in the 1990's. The U.K.'s A-3TK Polaris missiles will also be replaced by Trident D5 missiles.

At the present time, intercontinental ballistic missiles in service are primarily deployed by the Soviet Union and the U.S. On the basis of the strategic arms reduction treaty, it is estimated that, in the 1990's, the numbers of the type of missile in question will be greatly reduced. According to reports, Kazakhstan and Ukraine have already agreed to destroy by melting or burning the SS-18, SS-19, and SS-24 missiles within their borders. Within the next two or three years, Russia will also stop making use of SS-11, SS-13, SS-17, and SS-N-8 missiles.

If the second phase of the strategic arms reduction treaty is ratified, in the year 2000 or 2003, Russia will destroy by melting or burning SS-18, SS-24, as well as part of the SS-19 missiles. In conjunction with this, they will take the remaining SS-19 missiles and change them to single warheads.

Table 1 Intermediate Range Ballistic Missiles in the Process of Development

Close Range

Weapon System Nomenclature	Warhead Weight (Kg)	Maximum Range (Km)	Developing Country or Region
Haft 1	500	80	Pakistan
Haft 1A	500	100	Pakistan
Rohini	400	130	India
MB/EE150	500	150	Brazil
Prithvi 150	1000	150	India
Mushak 200	500	200	Iran

Alacran	500	200	Argentina
Prithvi 250	500	250	India
SS300	1000	300	Brazil
Haft 2	500	300	Pakistan
Fleet Footed			
Runner (SCUD) B	985	300	Iran
T Project	985	450	Egypt
Vector	450	600	Egypt
Haft 3	500	600	Pakistan
SS-600	500	600	Brazil
Al Abbas	300	900	Iraq (Suspended)
Condor 2	500	900	Argentina (Suspended)
Al Fatah	500	950	Libya
Tianma	500	950	Taiwan
Nodong 1	1000	1000	North Korea

Intermediate Range

Badr 2000	450	1200	Egypt/Iraq (Suspended)
Capricornio	500	1300	Spain
Arniston	1000	1500	South Africa
Al Aabed	750	2000	Iraq (Suspended)
Agni	1000	2500	India
S4	900	3500	France (Suspended)
M45	1000	4000	France (
ASLV	500	4000	India

Besides this, Russia may also stop the use of SS-N-18 submarine launched models of ballistic missiles--in conjunction with this, taking the numbers of warheads carried by SS-N-20 missiles and reducing them from 10 to 4. The U.S. will reduce LGM-30F Minuteman 2's as well as LGM-118 and Peacekeeper missiles. In conjunction with this, the numbers of warheads carried by LGM-30G Minuteman 3 missiles are reduced from 3 to 1. The numbers of

warheads carried by UGM-96 Trident C4 and UGM-133 Trident D5 missiles will be reduced from 8 to 4.

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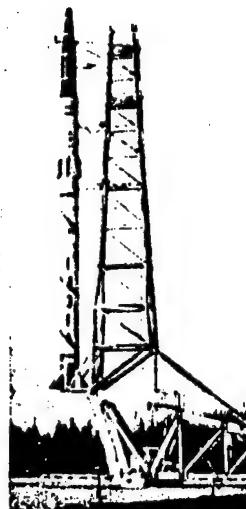


Fig.2 India's Agni Missile Prepared for Launch

Table 2 Cruise Missile Projects

Systems in Service

Weapon System Nomenclature	Warhead Weight (Kg)	Maximum Range (Km)	Country or Region
AS4	1000	400	Russia, Kazakstan, Ukraine, Byelorussia
AS6	1000	400	Russia, Byelorussia,

			Ukraine
SS-N-3	1000	450	Russia, Syria, Ukraine
BGM-109 Tomahawk	450	450/2500	U.S.
SS-N-12	1000	550	Russia, Ukraine
SS-N-19	750	550	Russia, Ukraine
AS-3	1000	650	Russia
AGM-86 ALCM	450	2500	U.S.
SS-N-21	300	3000	Russia
AS-15	300	3000	Russia
AGM-129 ACM	450	3000	U.S.

Systems Under Study

AGM-131 SCRAM2	265	400	U.S. (Suspended)
AGM/MGM-137	450	450	U.S.
No Details	No Details	600	India
CCM	410	600	Russia
AS-19	No Details	3000	Russia (Suspended)
SS-N-24	No Details	3000	Russia (Suspended)

France plans to continue implementation of missile development projects associated with M5 submarine launched models of missile. In conjunction with this, there is a possibility of continuing to develop S5 models of land based missiles.

Table 5 Cruise Missile Projects Which May Be Implemented

Nation or Region	Project Nomenclature
Brazil	SM-70 Banracula
France	ASMP, ASLP, Apache, C 22, ANS, Aotuomate

(Phonetic)

Germany	AS-34, Cormorant, ANS, MW-1
Iraq	Ababil, FAW200
Israel	Jiabolie (Phonetic) 4
Italy	Skyshark, Mirach 300, Aotuomate (Phonetic)
Japan	SSM-1, ASM-2
Russia	Kh-31, SS-N-25, ASM-MSS, SS-N-22
Sweden	RBS15, ASOM
Taiwan	Xiongfeng 2
U.K.	Seahawk (Illegible), MANTIS
U.S.	RGM-84 Harpoon, MQM-107, BQM-126, AQM-127, TBA324, AGM-136 Silent Rainbow, BQM-145

Such Russian submarine launched models and intercontinental ballistic missile development projects as the SS-X-26, SS-NX-26, as well as the SS-NX-27, and so on are already suspended. In conjunction with this, there is a possibility of cancelation. In the same way, the U.S. XMGM-134 small model intercontinental ballistic missile project has already been stopped in its implementation in 1992. In conjunction with this, there is a possibility of its being canceled.

In 1992, intermediate ballistic missile development projects of various nations were just in the process of unfolding. Iraq's Al Hussein, Al Abbas, and Al Aabed missiles were all developed on the foundation of Russia's Fleet Footed Runner (SCUD) missile. North Korea is just in the midst of implementing projects to copy and improve the Fleet Footed Runner (SCUD) missile. Iran has already produced its own Fleet Footed Runner (SCUD) B model missile. Egypt, by contrast--in the T project--carried out improvements with regard to the Fleet Footed Runner (SCUD) missile.

North Korea is just in the process of developing the Nodong 1 missile. The range of the missile in question is 1000km. This project is carried out in cooperation with Iran. Iran calls it Tondar-68.

As far as Argentina's Condor 2 missile project is concerned, although progress is not fast, it is still, however, in the process of being carried out. This is a missile project for which funding and technical assistance was supplied by Egypt and Iraq in the 1980's. In Egypt and Iraq, the Condor 2 is also called Badr2000. Compared to the Condor 2 missile, the warhead of the Badr2000 missile is comparatively small. Range is relatively long. However, the two projects may already have been canceled.

India's Agni missile project is aimed at proving the capability for developing intermediate range ballistic missiles. However, looking at the state of development of carrier rocket technology, India has the capability to produce intermediate range ballistic missile systems.

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Table 4 Intermediate and Close Range Ballistic Missiles in Service

Close Range

Weapon System Nomenclature	Warhead Weight (Kg)	Maximum Range (Km)	Using Nation or Region
SS-21	480	70	Byelorussia, Czech Republic, Hungary, Kazakhstan, Libya, Poland, Russia, Slovenia, Syria, Ukraine, Yemen
Puludong (phonetic)	400	120	France
Qingfeng	400	130	Taiwan
MGM 521 Lance	450	130	Belgium, Germany, Italy, Israel, Holland, U.K., U.S.
Iran 130 (Mushak 120)	500	130	Iran
ATACMS	450	135	U.S.
NHK-1	300	250	South Korea

SS-1 Fleet Footed Runner (SCUD) B	985	300	Afghanistan, Algeria, Azerbaijan, Byelorussia, Bulgaria, Czech Republic, Egypt, Georgia, Hungary, Iran, Iraq, Kazakhstan, Libya, North Korea, Poland, Rumania, Syria, Ukraine, Vietnam, Yemen, Russia, Slovakia
Hadesi (phonetic)	400	480	France
Jielike (phonetic) (YA-1)	500	500	Israel
Improved Model Fleet Footed Runner (SCUD)	500	550	North Korea, Iran, Syria
Al Hussein	500	650	Iraq

Intermediate Range

Jielike (phonetic) 2 (YA-3)	1000	1500	Israel
S3	1000	3000	France
SS-N-6	650	3000	Russia
M-4	1000	4000	France
A-3TK Polaris	1500	4630	U.K.
UGM-73 Poseidon	2000	4630	U.S.

Table 5 Intercontinental Ballistic Missiles in Service and Under Study

Weapon System	Reentry Warhead	Maximum Range (Km) Number	Using Nation or Region
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M5	10	11000	France (Under Study)
SS-11 (RS-10)	1	13000	Russia
SS-13 (RS-12)	1	9400	Russia
SS-17 (RS-16)	4	10000	Russia
SS-18 (RS-20)	1 or 10	11000	Russia
SS-19 (RS-18)	6	10000	Russia
SS-24 (RS-22)	10	10000	Russia
SS-25 (RS-12M)	1	10500	Russia
SS-X-26	No	No Details	Russia (Under Study)
		Details	
SS-N-8	1	7800	Russia
SS-N-18	3	6500	Russia
SS-N-20	10	8300	Russia
SS-N-23	4	8300	Russia
SS-NX-26	No	No Details	Russia (Under Study)
		Details	
SS-NX-27	No	No Details	Russia (Under Study)
		Details	
LGM-30F	1	12500	U.S.
Minuteman 2			
LGM-30G	3	13000	U.S.
Minuteman 3			
LGM-118	10	9600	U.S.
Peacockeep (MX)			
XMGM-134 SICBM	1	11000	U.S. (Under Study)
UGM-96 Trident C4	8	7400	U.S.
UGM-133 Trident D5	8	12500	U.S. U.K.



Fig.3 Tomahawk Missile Launched Aloft

During the 1991 Gulf War, cruise missiles played an important role. As a result, a number of countries will, in the 1990's, seek to develop similar missile systems.

After the signing of the first and second stage strategic arms reduction treaties, Russia's AS-19 and SS-N-24 missile projects will both already have stopped their implementation. However, there are a number of countries--for example, the U.S.--which are still carrying out the AGM/MGM-137 missile development project.

Such nations as Russia and France have already designed and manufactured missiles with ranges exceeding 3000 km--opting for the use of ramjet engine supersonic cruise missiles. Besides this, France, Israel, Italy, Japan, Russia, Sweden, the U.K., and the U.S. are still developing subsonic missiles with even longer ranges and opting for the use of turbojet engines. A number of box type or dropped type air missiles--for example, France's Apache--will develop into cruise missiles that are similar in range and warhead to the U.S. BGM-109 Tomahawk missile.

MODULAR STANDOFF WEAPON--APACHE

Gong Linru Zhai Baolin

Translation of "Mo Kuai Shi Fang Qu Wai Fa She De Dao Dan--Qiang Dao"; Aerospace China, No.6, June 1993, pp 45-46

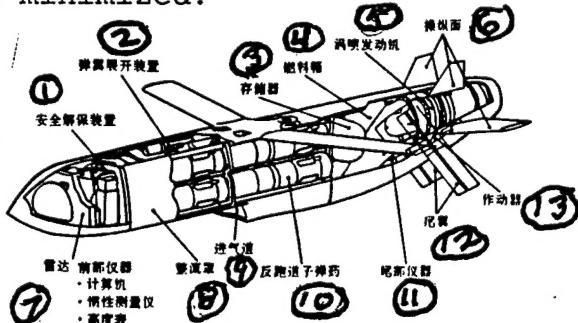
Apache is a type of standoff fired, modular missile weapon system in the development of which the French Matela (phonetic) company is prime contractor and the France spaceflight company is the main subcontractor--carrying out deep attacks at any time, in all weathers in enemy air defense and electronic warfare environments. It is air dropped from aircraft at long ranges and used in the carrying out of various types of missions such as attacking airfields, destroying tanks, blockading areas, and so on. Due to the fact that, when carrying maximum useful loads, its drop ranges can reach 150km, this is 3 times the range of traditional standoff fired weapons. Therefore, carrying aircraft are capable of dropping at comparatively long ranges in order to guarantee the safety of flyers. Besides this, missiles themselves are also capable of selecting appropriate flight paths to reach defense penetration objectives.

With the disintegration of the Soviet Union and the end of the state of East West Cold War--as far as today's repeated occurrence of regional conflicts is concerned--due to the indeterminate nature of the objects of operations, this type of modularized weapons system--like the Apache--are attracting even more attention than they did in the past. Because what they opt for the use of is modularized design, during utilization, it is possible, on the basis of different mission requirements, to deploy different useful loads. Speaking in terms of most nations, this is very attractive.

This is also nothing else than to say that one aircraft is capable of carrying out multiple types of missions, that is, achieving victory in war at the lowest price.

Due to this type of missile being fired at long range, it is not possible to carry out target indication on board the aircraft. Actually, it is a type of "fire and forget" missile. During weapon system development, the three necessary conditions below are considered. One is that there must be basic data collection systems--including data collection through satellites. Second is that there must be advanced mission planning systems. Third is that there must be advanced navigation and guidance systems. Moreover, these three systems must be capable of complete compatibility with each other, which is very important. Besides this, through reducing the easily attacked nature of missiles and improving terminal guidance capabilities, one obtains comparatively high first time hit probabilities.

Through reducing missile target characteristics, opting for the use of unusually low terrain tracking altitudes, and optimization of missile flight paths (on the basis of already known enemy air defense deployments and characteristics, making use of terrain, and considering characteristics of the missile itself) as well as other similar measures, the possibility of missiles being subject to attacks is minimized.



Schematic Lay Out of the Apache Missile

Key: (1) Safety Release System (2) Missile Wing Deployment System (3) Storage Device (4) Fuel Tank (5) Turbojet Engine (6) Control Surfaces (7) Radar Forward Section Instruments - Computers - Inertial Measurement Instruments - Altimeters (8) Cowling (9) Air Intake (10) Antirunway Submunitions (11) Tail Section Instruments (12) Tail Planes (13) Impeller

From predesigned missile trajectories calculated out before hand by mission planning systems, in conjunction, relevant trajectory data is fed to missile computers. After launch of the missiles in question, the navigation systems precisely track trajectories which are designed beforehand. This type of missile has very great flexibility in the selection of launch points. For this reason, it is possible to launch within a very large area.

At the present time, use of basic navigation and guidance systems for which option is made is appropriate for all missions. Moreover, guidance radars possess development potential. In order to improve terminal guidance precision, it is also possible to use other guidance heads in order to carry out supplementation--for example, opting for the use of infrared imagery guidance heads.

Below--on the basis of materials made public by the French Matela (phonetic) company--a simple introduction is made of the Apache weapon system.

The Apache missile is 5.1 meters long. It opts for the use of turbojet engines. The thrust is 5340 newtons. Fuel comsumption rates are low. The missile body has gone through optimization design and possesses good cruising efficiency and very small target characteristics. The wings and partial tail fins opt for the use of folding methods. Structures are compact and convenient to carrying on aircraft.

In the areas of missile fuselage structure and systems design, the Apache missile opts for the use of modularized plans. Modularized useful load compartments are capable of fitting various types of useful loads. It is not only possible to mount cluster munitions. It is also possible to fit single warhead combat sections. Ammunition dissemination systems are also mounted within useful load compartments. Originally, the useful load associated with the development of the Apache missile was cluster rounds capable of disseminating 10 Kriss used to attack airfield runways.

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Use of certain navigation and guidance equipment for which option was made in association with the Apache missile is capable of being precisely specified on the basis of mission requirements. Navigation and guidance systems which are under development include inertial measurement components, main computers, and radar altimeters. During missile cruising periods, they supply navigation and continuous altitude corrections as well as providing guidance and control commands. Besides this, there is also a forward looking radar used in steering corrections as well as flight terminal phase target detection and identification. At the present time, detection and identification opt for the use of digital type data. The data are supplied by mission planning systems. Data come from many types of channels. Among these are included satellite photos.

Due to opting for the use of navigation means and methods described above, even if all inertial components are not that advanced, it is still possible to guarantee the missile's ability to accurately fly a preset course.

The French Air Force is in the midst of carrying out integrated operations associated with the Apache missile and the Mirage 2000D as well as Wind Gust aircraft. The Apache missile is projected to enter service in 1997.